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DRT	Tomas Andersson	Tomas Andersson	2019-01-15	DRyynnnSEPTA	E	Draft

TRACS Computer Manual

Propulsion and Braking

SEPTA NHSL N-5 CAR

1 Revision

Version	Date	Description
0		First version.

2 Introduction

This document describes the propulsion and braking control software in the TRACS computer for the SEPTA NHSL N-5 car.

3 System Description

The propulsion and braking system on the SEPTA NHSL N-5 car is controlled individually on each truck. Computer A controls the motor converter and the friction brakes of truck A. Computer B controls the motor converter and friction brakes of truck B. Each computer are capable of controlling its converter and friction brakes independent from the other computer. This separation makes it possible to continue operation with one of the computers out of order, although the performance will be reduced.

4 Software Description

4.1 General

Most program modules for propulsion and braking are identical, or in many cases only differentated by the signal names for axles, etc, in computer A and B. Whether a program module is identical, only differentiated by signal names or different in computer A and B, are identified by the 3:rd position in the module name. The letter X, e.g., TMXGX, identifies a program module that are identical in computer A and B. The number 1/2, e.g., TM1S/TM2SA, identifies a program module that have different signal names but are functionally identical in computer A (1) and B (2). The letter A/B, e.g., TMAWE, identifies a program module that are only executing in one of the computers, although there may be a similar program module in the other computer.

Some program modules are only executing in propulsion or braking, normally with very similar program modules for propulsion and braking respectively. These program modules are normally identified by having a P (propulsion) or B (braking) in the 4:th position in the module name, e.g., TM1PD/TM1BD.

4.2 Trainline Decoder

4.2.1 TMXGD, Trainline Decoder

This program module decodes the propulsion and braking electrical trainlines to a propulsion or brake mode.

The propulsion/brake trainlines are decoded according to the following valid trainline patterns:

Propulsion/ Brake Level	**Trainline**										
	PO	**BR**	**B5**	**B4**	**B3**	**B2**	**B1**	**P1**	**P2**	**P3**	**P4**
Power 4	1	0	1	1	1	1	1	1	1	1	1
Power 3	1	0	1	1	1	1	1	1	1	1	0
Power 2	1	0	1	1	1	1	1	1	1	0	0
Power 1	1	0	1	1	1	1	1	1	0	0	0
Coast	0	0	1	1	1	1	1	0	0	0	0
Brake 1	0	1	1	1	1	0	1	0	0	0	0
Brake 2	0	1	1	1	1	0	0	0	0	0	0
Brake 3	0	1	1	1	0	1	1	0	0	0	0
Brake 4	0	1	1	1	0	1	0	0	0	0	0
Brake 5	0	1	1	1	0	0	1	0	0	0	0
Brake 6	0	1	1	0	0	0	1	0	0	0	0
Brake 7	0	1	0	0	0	0	1	0	0	0	0
Emergency	0	0	0	0	0	0	0	0	0	0	0

Any other combination is invalid. A propulsion and braking trainline pattern must be present for 200 ms before it is accepted.

4.2.2 TMXGS, Trainline Supervision

This program module supervises the propulion and braking trainline decoder and generates an output signal indicating the requested propulsion and braking mode.

The last detected valid trainline pattern will be held until a new valid pattern is detected, but no longer than 2 seconds. Trainline fault is indicated if no valid combination is detected for 2 seconds.

The car will default to coast if no valid trainline pattern is detected for 2 seconds and all the braking trainlines are ok, i.e., BR deenergized (0) and B1-B5 energized (1) .

The car will default to B5, friction brake only, if no valid trainline pattern is detected for 2 seconds and any braking trainline is not ok.

The fault signal F_TRLINE indicates that no valid trainline code has been detected the last 2 seconds. The trainline code present on the input board at the leading edge of the fault signal is stored in two bytes in the non-volatile RWM.

	address\bit	#7	#6	#5	#4	#3	#2	#1	#0
Power trainlines	$10FF03				P0	P4	P3	P2	P1
Brake trainlines	$10FF05			BR	B5	B4	B3	B2	B1

This program module also generates the signals PROP_EN and BRAKE_EN, controlling if the propulsion or the braking program modules shall be executed. The propulsion program modules are executed in coast and all power modes (PROP_EN=1). The braking program modules are executed in all braking modes (BRAKE_EN=1).

The braking program modules will always be executed (BRAKE_EN=1) when the brake trainline is energized (TL_BR=1), the emergency brake trainline is deenergized (EMBRAKE=1) or the penalty brake trainline is deenergized (FOVERSP=1).

At least brake level B5 is selected if the penalty brake trainline is deenergized (FOVERSP). Any more restrictive brake level (B6, B7 or emergency brake) is selected when requested. If the trainline code does not indicate B5, B6, B7 or emergency brake within ? ms (TMX??P02), the fault signal FUSPREL is set to indicate that there is a fault in the ATC underspeed relay. The following fault is indicated:

XXX ???

The selected propulsion or braking mode is indicated with the signals POWER4, POWER3, POWER2, POWER1, COASTING, BRAKE1, BRAKE2, BRAKE3, BRAKE4, BRAKE5, BRAKE6, BRAKE7 and EMERGENC.

The signals TRAINLIN and TLCODE indicates the selected trainline code as an arithmetic value to be able to easily record the mode on a graph. Each mode corresponds to a voltage with coasting being 0 V. TRAINLIN is the absolute value of TLCODE to have a better resolution on the graphs.

Mode	TRAINLIN	TLCODE
Power 4	4 V	4 V
Power 3	3 V	3 V
Power 2	2 V	2 V
Power 1	1 V	1 V
Coast	0 V	0 V
Brake 1	1 V	-1 V
Brake 2	2 V	-2 V
Brake 3	3 V	-3 V
Brake 4	4 V	-4 V
Brake 5	5 V	-5 V
Brake 6	6 V	-6 V
Brake 7	7 V	-7 V
Emergency	10 V	-10 V

4.3 Propulsion Control

4.3.1 DMAFA, General Fault Handling

This program module supervises following fault signals:

Overtemp. indication for electronic cubicle

CB for air cooler fan in U20 tripped

DC 15 V fault in computer A

Inverter blower fault in U20

Voltage door control (Speed less than 5 mph relay)

Line breaker is opened when:

DC 15 V fault occur in computer A

Air cooler blower fault occur

4.3.2 TM1FA, Motor Module Fault Handling

This program module supervises four fault indication signals:

CB blower TM&AA tripped

Overtemp indication brake resistor TM&AA

CB drive unit TM&AA tripped

Line breaker is opened when:

Brake resistor is overheated

Module contactor TM&AA is disconnected when:

Overtemp indication brake resistor is present

CB drive unit TM&AA is not restored before fault reset

Propulsion inverter TM&AA is blocked (disabled) when any of theese fault occur.

This program module also collects the fault signals that are generated from the inter-phase board DTCC509A_T and the fault signal from the DC link capacitor supervisory board.

Following fault signals are supervised:

DC-link capacitor fault

Commutation failure in an inverter branch

Drive unit fault

"General fault" from the DTCC 509A-T, this is one of following faults:

High GTO current.

Low supply voltage to the board.

Maximum number of instant current limitations has been reached.

The inverter branch fault detection from modulator super vision module is also OR grinded with commutation fault signal

4.3.3 TM1FB, Pt100 Element Fault Handling

This program module supervises the Pt100 element and will fault indicate if the resistance is too low or too high (short circuit or bad connection).

Following element is supervised:

Pt100 element Propulsion module heat sink TM&AA

4.3.4 TM1FC, High Temperature Fault Handling

This program module suprvises the temperature and will fault indicate if the measured temperature is too high. Two fault signals are set for each Pt100 element:

High temp indicates temp above normal.

Overtemp indicates the level when system disconnect to avoid any damage.

Normally, High temp is used only for Fault indication system texts. Overtemp will block and disconnect the faulty module and give another Fault indication system text.

Following elements are supervised:

Temperature Propulsion module TM&AA

An indicated fault on any temp sensor will substitute the measured, faulty value with a parameter value, P04.

4.3.5 TMAFB, Traction Motor Blower Supervision

The program module supervises the traction motor blower contactor.

When the CARWASH switch is pushed, the traction motor blowers are shut down for a period of P03 (s). After this time the fans are automatically started up again.

P04 s after the auxiliary power has started an order is given to the HVAC unit. The start order is named RUNAC. If the CARWASH is activated the HVAC unit will be stopped.

The HVAC is stopped to start the pump-down sequence 4 minutes after that STORAGE is entered.

The HVAC is stopped to reduce the auxiliary power load if there is a high temperature in the auxiliary converter or transformer.

4.3.6 TMABB, Traction Motor B Blower Control

This program module makes it possible for A computer to start traction motor blower B when computer A does not operate.

The conditions for this operation mode are:

SINGLE, that is that B computer is not executing

AUXPC_ON, AUX power is working

CARWASH is not active

The program module also supervises the traction motor blower contactor. A fault will,however, not stop the computer A from running AUX and propulsion A.

4.3.7 TMAFE, Motor Module Fault Handling

This program module collects all orders, created in computer A, to disconnect motor module A and transforms them into a sum signal. This sum signal corresponds to the output signal from a large OR-grid with all disconnect orders as input signals.

The purpose of creating this sum signal is to get a better overview and check of that all disconnect orders will be executed. At the same time, the number of signals to other program modules will be essentially reduced.

4.3.8 TMAFF, Disconnect Motor Module B Order

This program module collects all orders, created in computer A, to disconnect motor module B and transforms them into a sum signal. This sum signal corresponds to the output signal from a large OR-grid with all disconnect orders as input signals.

The purpose of creating this sum signal is to get a better overview and check of that all disconnect orders will be executed. At the same time, the number of signals to other program modules will be essentially reduced.

4.3.9 TMAFD, Block Motor Module Order

This program module collect the block requests that are generated in other program modules.

Output from This program module are three block requests:

block with slow fading of the torque referens

block with fast fading of the torque referens

block with momentarily reduction of the torque referens

The inverter block will not take place before the torque reference is almost zero.

4.3.10 TM1DB, Deblock Motor Module

This program module includes the deblock logic for the traction module.

The traction module is deblocked when all three deblock signals are true:

DBSLOTM&AA Slow block/deblock order

DBQUITM&AA Quick block/deblock order

DBMOMTM&AA Momentan block/deblock order

Deblock signal to propulsion modulator board (DEBLM&11) is derived from the three signals above. DEBLM&11 is set true when:

DBSLOTM&AA and DBQUITM&AA and DBMOMTM&AA = true

DEBLM&11 is set false when:

DBMOMTM&AA = false or

DBQUITM&AA or DBSLOTM&AA = false and TQTOSS_&AA = false

(TQTOSS_&AA = torque to spin slide system)

DBSLOTM&AA is true when following conditions are true:

Master controller in run or standby

Handler in position forward or reverse

Traction module not cut out with this switch

Contactor for traction motor blower closed or CARWASH (M&AABLCLD off signal delayed P5 sek.)

No block signal (BSTM&AA_B8) from other modules

Master controller not in B1 to B7 or EM. Block signal is obtained when the controller has been in brake pos with speed less than 1 mph for at least P4 ms.

DBQUITM&AA is true when following conditions are true:

Linevoltage greater than TM&11DBP3 volt

Linebreaker closed

Module contactor closed

No block signal (BQTM&AA_B8) from other modules

DBMOMTM&AA is true when following conditions are true:

No block order (BMOMTM&AA_B8) from other modules

No line breaker open order (LINEBOP&AA) from other modules

4.3.11 TM1FG, Motor Module Contactor Fault Handling

Supervision of the traction module contactor is done by comparing the close order MCTM&AACL with the contactor closed indication MCTM&AACLD. If there is a difference between the two signals for more than TM&11FGP01 ms, a fault signal is given to the FIS (MCTM&AA_I = True).A block signal is also given to the line circuit breaker and the module contactor (MCTM&AA_D = True).

If there is a request from one or more other program modules to open the module circuit breaker (signal AMCTM&AA_D or BMCTM&AA_D) the line circuit breaker is automatically opened via the output signal LB_OP&AA6. When the module contactor is opened the circuit breaker is allowed to close again after a time delay TM&11FGP02 ms.

4.3.12 TM1MC, Motor Module Contactor Logic

This program module controls the TM&AA module contactor. The contactor shall only be operated when the line voltage is zero (LVGTZERO = FALSE) and the circuit breaker is open. (LINEBCLD = FALSE).

4.3.13 TMAEM, Energy Measuring

This program module generates the pulses to the meters showing consumed and regenerated energy.

The power system voltage and current are multiplied and integrated by the software, generating a pulse train, where every pulse represents an energy amount of 1 kWh.

Currents with absolute values beneath 5 A is considered as 0 A to prevent integration errors due to the accuracy of the measuring instruments.

4.3.14 TMAOM, Odometer

This program module generates the pulses to the odometer. The car speed is integrated and every tenth-mile a pulse is given as output from the subfunction.

4.4 Propulsion and Dynamic Braking Control

4.4.1 TMXPS, Speed Reference Select Logic

This program module selects the speed reference related to the present propulsion mode(s).

Propulsion Mode Speed Reference

CAR WASH, POWER1 2 mph

PAN POSISION 10 mph

ATC Cut Out 35 mph

Underspeed relay fault 35 mph

Friction brake fault 35 mph

POWER2 - 4 80 mph

Cruise Control Current speed

If more than one propulsion mode is active, the lowest speed reference of the selected is dominant.

The Cruise Control mode is achieved, when the master controller is moved from POWER3 or POWER4 down to POWER2 and the system is held in this mode until the master controller moves to another position.

4.4.2 TMXPR, Speed Regulator

This program module contains a P-regulator to control the speed in propulsion.

The speed, at which the speed regulator shall contribute the tractive effort reference, is considered as reached when the speed equals the speed reference minus an offset and will so be considered until the speed has decreased beneath a specified level, defined by a comparator's hysteresis. This condition is indicated with a signal.

4.4.3 TMXPA, Acceleration Reference Select Logic

This program module selects the tractive effort reference (corre- sponding to a wanted acceleration at AW1 load) related to the present propulsion mode(s).

Propulsion Mode Tractive Effort Reference

COASTING 0 kN

POWER1,CAR WASH, Speed regulator contribution

Cruise Control or when speed reference is reached

POWER2 or when a 9.7 kN (-> 1.0 mph/s)

speed sensor failure is present or when overtemp computer ind

POWER3 or ATCCO 19.4 kN (-> 2.0 mph/s)

POWER4 29.0 kN (-> 3.0 mph/s)

If more than one propulsion mode is active, the lowest tractive effort reference of the selected is dominant.

4.4.4 TM1PL, Load Weighing

This program module modifies the tractive effort reference in a way that makes the car acceleration independent in a certain load interval. As an example, the acceleration in POWER4 propulsion mode shall be the same when the car carries an AW0 load as when it carries an AW1 load.

Figure Tractive Effort vs Load weigh

4.4.5 TMXBA, Braking Reference Select Logic

This program module selects the braking effort reference (corresponding to a wanted retardation rate at AW1 load) related to the present braking mode(s).

Braking Mode	Braking Effort	Reference (AW1 load)
COASTING	0 kN	0 mph/s
BRAKE1	3.5 kN	0.4 mph/s)
BRAKE2	7.1 kN	0.8 mph/s)
BRAKE3	10.6 kN	1.2 mph/s)
BRAKE4	14.2 kN	1.6 mph/s)
BRAKE5	17.7 kN	2.0 mph/s)
BRAKE6	22.2 kN	2.5 mph/s)
BRAKE7	26.6 kN	3.0 mph/s

For brake levels 6 and 7 special retardation rates are demanded over the speed of 60mph.

At brake level 7 the retardation rate over 60 mph is at least (6-0.05V) mph/s, where V is the car speed in miles per hour. At speeds less than 60 mph the retardation rate is 3.0 mph/s.

At brake level 6 the retardation rate over 60 mph is not exceeding (6-0.05V) mph/s. At speeds less than 60 mph the retardation rate is 2.5 mph/s.

If more than one braking mode is active, the highest braking effort reference of the selected is dominant.

If the penalty brake trainline is energized or if the pantopraph is raised without order, the retardation controller will produce a brake reference corresponding to brake level 5.

Emergency brake or undefined trainline code will request brake level 7.

4.4.6 TM1BL, Load Weighing

The task of the load weighing system is to keep the retardation rates as constant as possible at varying car loads, up to AW2 at negative tractive effort (braking)

This subfunction modulates the required braking effort, so that the deceleration rates will be constant at each brake level, independent of the actual car load weight. The deceleration will be independent of the car load between AW0 and AW2 at dynamic braking. See 2.6.2, 2.6.3 & 12.1.

E.g. brake level 5 shall produce an deceleration rate of 2.0 miles/ hour/second at the load AW2 as well as at the load AW0. The braking effort will therefore be reduced to about 86% at AW0, compared to AW1.

Note that the friction brake system has its own pneumatic load weighing system, which will function between AW0 and AW3.

Figure Tractive Effort vs Load Weigh

4.4.7 TM1GL, Load Weighing Supervision

This program module supervises the load weight signal of one truck. If the signal is not within a defined interval, i.e. lower than the low limit or higher than the high limit, the signal is considered as faulty and an error signal is given.

The supervision is only carried out when the air compressor is not running, i.e. the main reservoir has been pressurized.

4.4.8 TM1FL, Fault Handling Load Weighing

This program module performs the fault handling of the load weighing signal of truck &AA.

The module generates a fault indication signal to the FIS and a fault signal to be used by other program modules.

4.4.9 TM1GT, Torque Reference Calculation

This program module calculates the torque reference corresponding to the tractive or braking effort reference of truck &AA, forming the input signal of This program module.

The calculation is made with the formula:

Tq = ((k&12 + k&22) / (2 2pi p)) F

Tq = Torque reference of truck &AA

kx = Gear exchange factor of axle x

p = Number of pole pairs = 2

F = Tractive or braking effort reference of truck &AA

The scale factor ((k&12 + k&22) / (2 2pi p)) is given as output signal to be used in other programs.

4.4.10 TM1PT, Maximum Torque Limitation

This program module calculates truck &AA's maximum allowable torque as a function of the motor speed in propulsion.

The function is based upon the diagram, describing maximum allowable tractive effort of the whole car as a function of car speed when the car is equipped with new wheels.

The parameters of the module are taken from the above mentioned diagram. These are then, by the module itself, scaled from car tractive effort and car speed values to the corresponding truck torque and motor speed values.

If a wheel diameter fault is present, the maximum allowable torque is reduced to half of the normal value. This to prevent overload of a single motor in a truck. A too big difference in wheel diameters will lead to a bad load sharing between the motors.

4.4.11 TMXPT, Propulsion Reference Source

This program module performs the fault handling of the trainline.

Two seconds (TMXGSP01 in Train Line Supervision module) after the last valid trainline command a fault signal F_TRLINE is set. From the communication module corresponding signal FTRLINEO from the other computer is received.

This program module decodes the Train line fault signals received from both A and B computer. The Fault trainline signal is active if there is an invalid trainline code for more than TMXGSP01 sec (2 seconds).

F_TRLINE: Trainline fault signal from "own" computer.

FTRLINEO: Trainline fault signal from "the other" computer.

COMM_RUN: Paralell communication is operating.

MASTER : "Own" computer is master.

F_TRLINE FTRLINEO COMM_RUN MASTER TMXPTTER 0 0 0 0 TMXPATER

0 0 0 1 TMXPATER

0 0 1 0 TMXPATRO

0 0 1 1 TMXPATER

0 1 0 0 TMXPATER

0 1 0 1 TMXPATER

0 1 1 0 TMXPATER

0 1 1 1 TMXPATER

1 0 0 0)

1 0 0 1)

1 0 1 0 TMXPATRO

1 0 1 1 TMXPATRO

1 1 0 0)

1 1 0 1)

1 1 1 0)

1 1 1 1) where TMXPATER is "own" tractive effort reference

TMXPATRO is tracive effort reference from "other" computer.

) means that the reference:

first is frozen for P02 ms

then reference is set by P01 value

after additional P03 ms computer is stalled.

4.4.12 TM1BT, Maximum Torque Limitation

This program module calculates truck &AA's maximum allowable torque as a function of the motor speed in braking.

The function is based upon the diagram, describing maximum allowable tractive effort of the whole car as a function of car speed when the car is equipped with new wheels.

The parameters of the module are taken from the above mentioned diagram. These are then, by the module itself, scaled from car tractive effort and car speed values to the corresponding truck torque and motor speed values.

If a wheel diameter fault is present, the maximum allowable torque is reduced to half of the normal value. This to prevent overload of a single motor in a truck. A too big difference in wheel diameters will lead to a bad load sharing between the motors.

4.4.13 TMXBT, Braking Reference Source

This program module performs the fault handling of the trainline.

Two seconds (TMXGSP01 in Train Line Supervision module) after the last valid trainline command a fault signal F_TRLINE is set. From the communication module corresponding signal FTRLINEO from the other computer is received.

This program module decodes the Train line fault signals received from both A and B computer. The Fault trainline signal is active if there is an invalid trainline code for more than TMXGSP01 sec (2 seconds).

F_TRLINE: Trainline fault signal from "own" computer.

FTRLINEO: Trainline fault signal from "the other" computer.

COMM_RUN: Paralell communication is operating. F_TRLINE FTRLINEO COMM_RUN TMXBTBRR 0 0 0 TMXBABRR

0 0 1 TMXBABRR

0 1 0 TMXBABRR

0 1 1 TMXBABRR

1 0 0)

1 0 1 TMXBABRO

1 1 0)

1 1 1)

where TMXBABRR is "own" braking effort reference

TMXBABRO is braking effort reference from "other" computer.

) means that the reference:

first is frozen for P02 ms

then reference is set by P01 value

after additional P03 ms computer is stalled.

4.4.14 TM1BN, Torque Limitation Due to Low Speed

This function describes the maximum torque reference as a function of the velocity of the car. The braking effort is reduced for low speeds in order to cause a smooth stop for the car.

Figure Braking Effort vs Speed

4.4.15 TMABO, Torque Limitation Due to Overvoltage Choppers

When all overvoltage choppers are enabled, 100 % dynamic braking reference is allowed. The dynamic braking reference must sometimes be reduced if at least one chopper is disabled. Depending on the number of closed traction motor module contactors, the dynamic braking reference reduces different: Both traction motor modules are closed For each chopper disabled, the dynamic braking reference to each traction inverter is reduced with 25 %. Only one traction motor module contactor is closed If at least two choppers are enabled, there is no reduction of the dynamic braking reference. If only one chopper is enabled, the dynamic braking reference is reduced with 50 %. Disable of dynamic braking reference In some cases the dynamic braking reference is disabled due to different faults:

if both traction motor module overvoltage choppers are disconnected due to drive unit fault

if all overvoltage choppers are blocked due to phase logic power supply fault

if there is something wrong with the slave computer DTCC102B.

If the maximum allowed dynamic braking reference is greater than zero, at least one overvoltage chopper is enabled. If at least one overvoltage chopper is enabled, it is possible to close the line capacitor charging contactor.

4.4.16 TM1BS, Snow Brake

The task of the snow brake is to keep the brake discs warm and dry, so that ordinary friction braking can be applied at request without delay.

If the snow brake contact rocker in the active cab is turned on and the master controller is in any of the seven possible brake positions, the snow brake function will activate. This means that the dynamic brake is reduced so that at least one step of blending takes place with each brake application, i.e., brake level one will become friction brake only braking. The snow brake function will not produce any friction braking if the master controller is in power or coasting position.

Level 1 brake (in pu) is subtracted from the load w compensated friction brake reference. The result is added to the dynamic brake reference. This is equivalent to that the dynamic brake reference is reduced exactly so much that the blending will cause friction brake level 1 in case of snow brake request.

When the snow brake function is active, the output signal Snow Brake Indication will also be active. This output signal will via trainline light an amber LED in all active cabs in the train.

When the contact rocker in the cab is turned off, the snow brake will cease and the LEDs in the cabs will be turned off. This is implemented with an RS flip flop.

4.4.17 TM1GS, Torque Limitation Due to High Temperture

The task of this subfunction is to reduce the tractive effort to protect the inverters in case of overtemperature. If the temperature of any of the two propulsion inverters increases over a certain specified level, the tractive effort reference to the overheated inverter will be reduced proportionally to the temperature.

If the air temperature in the power electronic box reaches a specified level, the tractive effort references for the two propulsion inverters will both be reduced proportionally to the temperature. This because the propulsion inverters produces most of the heat in the power electronic box.

In all cases described above different digital overtemperature signals will tell the Fault Indication System that overtemperature has been detected.

The reduction of the tractive effort is made upon TQ_MAX_&AA, which means that the maximum allowed torque in Nm is different for different velocities. Please note that the first thing to do if this reduction has to be decreased, is to let it affect the torque maximum directly and not via TQ_MAX_&AA as originally specified.

Default temperatures, giving no tractive effort reduction, are used if temperature sensor faults are indicated.

4.4.18 TM1GU, Torque Limitation Due to Line Voltage

The task of this subfunction is to reduce the torque reference at low line voltage.

If the line voltage decreases under 630 V, this subfunction will reduce the torque reference proportionally to the line voltage. This will continue down to the level where the line voltage is 460 V. At this point the tractive effort shall be reduced to 0% of maximum T.E.

If the third rail power is very intermittent due to e.g. ice, then the torque reference limitation is inhibited. The signal POOR3R flags the poor third rail power condition.

4.4.19 TM1GJ, Jerk Rate Limitation

This program module limitates the jerk rate of truck &AA by limitating the torque reference of truck &AA.

Maximum allowable jerk rate is 2.0 mph/s/s and is controlled by a parameter based upon the formula:

m d (d/dt) Tq = --------- (d/dt) a 2 p g

Tq = motor torque

m = weight

d = wheel diameter

p = number of pole pairs = 2

g = gear exchange = 5.67

a = acceleration

The output signal of the module is a modified version of the torque reference representing the input signal of the module.

TQFRJR_&AA is ramped to zero when:

PSIOKM&11 = false or

DBMOMTM&AA = false or

DBQUITM&AA = false or

DBSLOTM&AA = false or

TM&11GJ149 = false

DBACKM&11 = true gives CF with FOLLOW = 0.

IPCACT = true more than P02 ms gives FOLLOW with value TQTOFR_&AA.

Special Cases:

EMERGENCY or low values of TQFRJR_&AA when speed is below 5 mph will also change the ramp time.

Ramp up is set to

P05 normally

P04 if EMERGENCY brake is applied or TQFRJR_&AA less than P03 when speed less than 5 mph.

Ramp down is set to

P05 normally

P06 if DBQIUTM&AA is set false

P04 if EMERGENCY brake is applied or TQFRJR_&AA less than P03 when speed less than 5 mph.

At Intermittent Power Collection (IPC):

If the power interrupt is shorter than a certain time, the output signal of the module is left untouched. Else the output signal is made equal the input signal of the forward/ reverse detection module placed after this and the IPC Control module. This to prevent a too high jerk rate after a relative long power interrupt.

At Spin or Slide:

These states of the system do not influence This program module and are taken care of by modules after this one.

At Brake-to-Propulsion transitions (or reverse)

The transition (P -> B or B -> P) gives an signal (TM&11GJ149 No Propulsion-Braking TranSitioN, normally high). When the transition takes plays this signal goes low for TM&11GJP01 ms. When this signal is low the torque reference will be ramped down to zero. This signal also makes the Forward/Reverse handler module not to change sign of its output reference TORQUER&AA. This means that when the reference is ramped down it will still have the original direction of torque.

When the torque reference TQFRJR_&AA goes under a certain level decided by TM&11GJP03 the signal TM&11GJ149 goes high and thus allows the Forward/Reverse handler to change the sign of its output reference. A time out circuit will not permit to long waiting for TQFRJR_&AA to get below P03.

At Emergency Braking:

The output signal of the module is ramped with a faster ramp (TM&11GJP04)

Torque reference is limited in propulsion to what is maximum available with the signal PROPLIM. There is no limitations in braking.

Reference for friction brake TQFBJR_&AA is also calculated in this modul. Torque is basically the same as TM&11GTTQR which is very close to Master Controller signal, but TQFBJR_&AA is ramped up and down. Also, when Master Controller is moved from Brake to Propulsion position, TQFBJR_&AA will be set to zero by Control Follow, Ramp element .300. This will give a quick brake release when starting up.

4.4.20 TM1PM, Torque Limitation Selection Logic

This program module limits the torque reference in propulsion of truck &AA according to:

the torque corresponding to the tractive effort reference

the maximum torque allowed

the maximum torque allowed due to temperatures

the maximum torque allowed due to line voltage

The most restrictive limitation is named PROPLIM

4.4.21 TM1BM, Torque Limitation Selection Logic

This subfunction decides the maximum torque allowed in braking according to brake trainlines, temperatures, speed, line voltage and regeneration cut-out switch.

The electrical brake torque is limited to zero if there is no power on the line, i.e. if intermittent power collection is active (IPCACT), when brake mode is entered; or if carwash control is active.

Regenerative cut-out logic:

The line breaker is ordered open when the regenerative cut-out switch is activated, i.e. REGCO_N is false, and braking is selected. The maximum electrical brake torque reference is reduced proportinal to the speed at low speeds to smoothly change over to friction braking.

The line breaker is closed again when brake mode is not selected, or if the dc link voltage cannot be maintained by the dynamic brake.

The dynamic brake is limited to zero when the line breaker is closed, except at initiation of the braking.

4.4.22 TM1PD, Spin Detection

The wheel spin detection system shall detect any case of wheel spin, synchronous or asynchronous, and then reduce the acceleration effort so that the wheel spin will cease as soon as possible.

There are basicly two different cases of wheel spin:

One or two axles of the car spins.

All four axles of the car spins synchronously.

To detect case 1 spin the speed of each of the four axles is compared to the true car speed, after the wheel size calibration. If any significant difference is detected, wheel spin is at present. The detection will be as sensitive as possible, and react at the lowest surely detectable speed difference, as far below 3 miles/hour as possible.

To detect case 2 spin we look at the rate of change of velocity. If this rate is higher than the maximum acceleration rate for a sufficiently long time, wheel spin is at present.

Please note that the DER element ought to be executed on T3 in order to get sufficient accuracy in the retardation value.

T3 = 60 ms <-> accuracy of 0.051 mph/s

T2 = 12 ms <-> accuracy of 0.254 mph/s

Before the first wheel size calibration has been performed, the detection of wheel spin will be less sensitive.

4.4.23 TM1PP, Spin Protection

The wheel spin protection system shall reduce the acceleration effort so that the wheel spin will cease as soon as possible. When wheel spin is at present, the dynamic brake reference will be reduced, so that the wheel spin will cease.

When the wheel spin has ceased, the tractive effort will be resumed in a controlled way. First the reference will be put up rather quickly to about 60% of its original value by a fast ramp element. Then it will slowly be increased to its original value by a slower ramp element. This is made to avoid subsekvent wheel spin. If there has not been a new spin when slow ramp reach P08% (105%) then the slow ramp will be substituted with a quicker ramp.

The fast slope time is set to 200 ms (GS 90 ms, ISTAold 276 ms, ISTAnew 406 ms) (from 0 to max). The slow slope time is set to 2400 ms (GS 1802 ms, ISTAold 2300 ms, ISTAnew 2410 ms). This will have to be tuned.

Spin can be simulated by letting the parameter TM&11PPL01 = TRUE

4.4.24 TM1BD, Slide Detection

The wheel slide detection system shall detect any case of wheel slide, synchronous or asynchronous, and then reduce the deceleration effort so that the wheel slide will cease as soon as possible.

There are basicly two different cases of wheel slide:

One or two axles of the car slides.

All four axles of the car slide synchronously.

To detect case 1 slide the speed of each of the four axles is compared to the true car speed, after the wheel size calibration. If any significant difference is detected, wheel slide is at present. The detection will be as sensitive as possible, and react at the lowest surely detectable speed difference, as far below 3 miles/hour as possible.

To detect case 2 slide, we look at the rate of change of velocity. If this rate is higher than three times the maximum deceleration rate for a sufficiently long time, wheel slide is at present. The time-intervals discussed above shall be determined carefully, with the rotational inertia of the axles considered as a prime factor in the calculation. A worst case adhesion of 5 percent shall be assumed. (See 14.2.4)

Please note that the DER element ought to be executed on T3 in order to get sufficient accuracy in the retardation value.

T3 = 60 ms <-> accuracy of 0.051 mph/s

T2 = 12 ms <-> accuracy of 0.254 mph/s

Before the first wheel size calibration has been performed, the detection of wheel slide will be less sensitive.

4.4.25 TM1BP, Slide Protection

The wheel slide protection system shall reduce the deceleration effort so that the wheel slide will cease as soon as possible. When wheel slide is at present, the dynamic brake reference will be reduced, so that the wheel slide will cease.

When the wheel slide has ceased, the braking effort will be resumed in a controlled way. First the reference will be put up rather quickly to P04 % (85%) of its original value by a fast ramp element. Then it will slowly be increased to its original value by a slower ramp element. This is made to avoid subsekvent wheel slide. If there has not been a new slide when slow ramp reach P08% (105%) then the slow ramp will be substituted with a quicker ramp.

The friction brake blending will be suppressed when the dynamic braking is reduced during slide correction activities.

The fast slope time is set to 200 ms (GS 90 ms, ISTAold 276 ms, ISTAnew 406 ms) (from 0 to max). The slow slope time is set to 2400 ms (GS 1802 ms, ISTAold 2300 ms, ISTAnew 2410 ms). This will have to be tuned.

Slide can be simulated by letting the parameter TM&11BPL01 = TRUE

4.4.26 TM1SS, Low Adhesion Detection

4.4.27 TM1SA, Sanding

Sanding is requsted at three occasions:

At spin indication

At slide indication

At emergency brake (unconditionally)

Sand is put on the rail in front of the leading cab only. Sanding is inhibited when the speed of the car is lower than 1 mph (VGT1.0 = false).

Following spin or slide cases are covered for:

Emergency brake.

Sanding is immediatly started and will continue until the speed is lower than 1 mph (VGT1.0 = false) or until emergency brake is reset.

Single, short spin or slide indications.

The first indication will be saved as number one in a counter (.150). If the second indication comes after a longer time interval than P02 ms the indications are considered to be single one's and the counter is reset between each indication. No sanding request is given. The reason is to avoid the car from spilling sand at each single indication.

Repeated spin or slide indications.

When spin or slide indications are coming repeatedly with a shorter time interval than P02 ms they will each one increase the value in the counter with "1". When the number of indications has counted to P01 sanding is requested.

Long spin or slide indications.

When a spin or slide indication is longer than P03 ms sanding is requested at once.

Each request for sanding is at least P04 ms long.

4.4.28 TM1MF, Torque and Rotor Flux Reference

This program module generates a rotor flux reference to the propulsion modulator board.

4.4.29 TM1GK, Inverter Model

This programme module will compensate for the imperfections that the inverter shows under different loads and frequencies.

The compensation is made with two models, model No 1 and model No 2. No 1 is active in the low frequencies (0 to 30-50 Hz) Model No 2 is active in the middle frequencies (30 - 50 up to 100 Hz).

Model No 1 gives a contribution to the stator resistance as output signal. This signal RCONTM&11 is sent to the TM&11MS module (signal definition for the slave) where this contribution is added to the stator resistance. This new stator resistance is then used in the motor parameter program TMMPAS in the slave.

Model No 2 works in a different way. This model calculates a contribution to the stator flux (DELPSIM&11). This value is sent to TM&11MS and from This program module sent down to the slave. The slave adds this contribution DELPSISM&11 to the calculated flux PSISREF.

In order to make a "soft" change from one model to the other a frequency dependent multiplication is made. When model No1 is decreasing in value, model No 2 is increasing.

The compensation is disabled when Master Controller is in position COASTING.

4.4.30 TM1GP, Intermittent Power Collection

This program module detects when the DC link voltage drops due to intermittent power collection. This will happen when the car is crossing the neutral sections of the catenary power, when the third rail is covered by ice or snow or when the car is leaning more than normal.

When an intermittent power collection is detected the torque reference will be forced to a slightly (dynamic) braking reference. This will have the effect that the DC link voltage is kept close to nominal line voltage.

Regeneration cut out (REGCU) switch in K41 will disable the intermittent power collection module.

When the power collection is disturbed this can be detected in one of three different ways:

The DC link voltage drops below a threshold value (P21)

The slope of the decreasing line voltage is high at the same time as the slope of the decreasing line current also is high. This is the case when the car is running through a neutral section with the Master Controller in P4 position.

The slope of the decreasing line voltage is low but constant (longer time than P99) at the same time as the line current is very low (lower than P98). This is the case when the car is running through a neutral section with the Master Controller in COASTING position.

The calculating elements are .90 for line voltage and .91 for line current.

Under normal power collection the torque reference is fed through the ramp element .335

When an intermittent power is detected the ramp element .335 is immediatly put into Control Follow mode. This will cause the output signal from the element to follow the FOLLOW input instead of the IN signal. The FOLLOW signal will give a slightly braking torque reference making the DC link voltage to increase due to dynamic braking. The braking torque reference is given from a RAMP element. The value of the input signal to this RAMP element is controlled by the value of the line voltage.

Reapplication of power is detected with the help of the line current. When the line current is greater than a certain value (P41) a time delayed signal (P53 ms) is resetting the ramp element to its normal mode of operation.

4.4.31 TM1GF, Forward/Reverse Logic

This program module controls the sign of the torque reference to the motor of truck &AA to achieve acceleration in the wanted direction.

The following rules are followed:

Forward Propulsion ! Sign of Torque

Wanted Wanted ! Reference

NO NO ! KEEP

YES NO ! CHANGE

NO YES ! CHANGE

YES YES ! KEEP

If the wrong car motion direction signal is true, the torque reference is set to zero.

The signal PROPING will decide when it is time to change sign on the signal.

4.4.32 TM1GE, Test Deblock of Propulsion Modulator

This program module makes it possible to test propulsion inverter &AA when the test switch is held in TEST position.

During test, This program module sets the torque control of inverter &AA in a test mode, where the controller and the inverter phases are enabled and the modulation patterns are reaching the thyristors without having any high voltage connected to the inverter. The modulation pattern corresponds to a rotor frequency, defined by a parameter in This program module. The module also makes sure, that the order of disconnecting inverter &AA from the line is carried out before the inverter phases are enabled in test mode.

This makes it possible to test the chain from the modulator pulse to the thyristor pulse in a safe way.

4.4.33 TM1MS, Propulsion Modulator Communication

This program module defines the signal names in the doubble port memory (propulsion modulator board memory).

As a part of the activation of the modulator board the parameters for the modulator are sent down.

Fault signals from the modulator board are presented with termtext element on a connected hand held terminal.

4.4.34 TM1MR, Propulsion Modulator Board Activation

The module has two main functions:

activation of modulator board DTCC121A

supervision of hard- and software malfunctions

When DEBLOCK order is given to the motor board modulator DTCC121A, a deblock acknowledge has to be present within TM&11MRP1 ms. The module will be disconnected after three (TM&11MRN4) fault indications.

The DEBLOCK order consists of three signals :

DBSLOTM&AA

DBQUITM&AA

DBMOMTM&AA

and all three of them has to be true.

The name of the acknowledge signal is DBACKM&11.

4.4.35 TM1FP, Torque Supervision

This subfunction calculates the inverter current direction and the achieved electrical torque to supervise the inverter control.

The direction of the current on the dc side of the inverter is supervised. The current is measured with a current transducer and connected to analog input channel 12 on DTAI101H-T via the signal adaption board DTAA502B-T. ID&AA is scaled so that #32767 represents +1000 A in to the inverter.

The inverter is blocked if the current exceeds +250 A in braking, i.e. when trainline BR is high or overspeed is indicated by the ATC, for more than 5 seconds

The electrical torque is calculated from the current on the dc side of the inverter, the dc link voltage and the speed:

T = UD ID/n

The inverter is blocked if the calculated torque and the achieved torque indicated by the inverter control differs more than ? A for more than 5 seconds

FTORQUE&AA is set to block the inverter if any of these faults are detected.

4.5 Overvoltage Chopper Control

4.5.1 DMXOG, Overvoltage Chopper System Program

This program module includes the following

Definition of a logical name for the slave.

Clear slave RWM.

Start the slave.

IREQ1 acknowledge.

External definitions of signals created in this pgm module and used in others.

Test points.

This program module is used to define the slave for the master. The slave is given a logical name which are used in other programs when using the DTCC102A element.The error flags from the slave are also given logical names.

During start up the slaves RWM area is cleared and after a "hand shake" procedure the slave is started. The acknowledge of a slave(S1) I1 request is also done in this program (if needed).

Flow chart:

Set a logical name for the slave.

Start up the slave.

START UP PROCEDURE

MASTER SLAVE

STOP THE SLAVE

CLEAR RWM ON THE SLAVE

RELEASE THE SLAVE

THE SLAVE GOES INTO A WAIT LOOP WAITING FOR A COMMAND TO RUN ITS INIT LEVEL.

GIVE THE SLAVE THE COMMAND TO START EXECUTE ITS INIT LEVEL.

IS THE SLAVE READY?

THE SLAVE RUNS ITS INIT LEVEL.WHEN IT IS READY IT INDIC. THAT TO THE MASTER.

SEND A COMMAND TO THE SLAVE TO START ITS "ORDINARY" DUTIES.

HAS THE SLAVE ACKNOWLEDGED?

ACKNOWLEDGE THE COMMAND AND START WITH THE "ORDINARY" DUTIES.

END START UP PROCEDURE END START UP PROCEDURE

Acknowledge the IREQ1 from the slave.It should be done on the I1 level.

4.5.2 TMAPT, Pt100 Element Supervision

This program module suprvises the pt100 element and will fault indicate if the resistance is too low or too high (short circuit or bad connection).

Following elements are supervised:

Pt100 element Overvoltage chopper heat sink TMA-TMB

Pt100 element Overvoltage chopper heat sink AUX

4.5.3 TMAFG, Temperature Supervision

This program module supervises the temperature and will fault indicate if the measured temperature is too high. Two fault signals are set for each Pt100 element:

High temp indicates temp above normal.

Overtemp indicates the level when system disconnect to avoid any damage..

Normally, High temp is used only for Fault indication system texts. Overtemp will block and disconnect the faulty module and give another Fault indication system text.

Following elements are supervised:

Temperature Overvoltage chopper heat sink AUX

Temperature Overvoltage chopper heat sink TMAB

An indicated fault on any temp sensor will substitute the measured, faulty value with a parameter value, P04.

4.5.4 TMAFO, Overvoltage Chopper Fault Handling

This program module includes the fault handling of the overvoltage choppers. Input signals are the three module voltages, status of breakers, contactors and switches.

Output signals are indication signals (signals that display fault texts on the FIS), blocking signals and disconnecting signals.

Three different faults are detected:

overvoltage chopper drive unit fault

overvoltage chopper phase logic low power supply

Four different FIS texts are used to indicate above faults, one for each chopper phase.

too big deviation between module voltages (UDIFF > 75 V)

This fault is indicated in the FIS as a measurement fault, one text for each module.

To big deviation between module voltages is detected in the following way:

If one module voltage deviates more than UDIFFLP V from the other two, the following happens:

all inverters are blocked

the line circuit breaker is opened

the DC-link is discharged

Overvoltage chopper drive unit fault

When an overvoltage chopper drive unit fault is detected, the faulty chopper is disabled by the phase logic and the maximum dynamic braking reference is reduced.

When fault reset is pushed and the fault disappears, the dynamic breaking reference reduction is removed.

If both traction module overvoltage choppers are disabled, also the dynamic braking is disabled.

Overvoltage chopper phase logic low power supply

When overvoltage chopper phase logic low power supply is detected, all choppers are disabled. The maximum dynamic braking reference is also disabled.

When fault reset is pushed and the fault disappears, the dynamic braking reference is enabled again.

This program module is only executing if the signal OVCC_ON is True.

4.5.5 TMAGP, Deblock of Overvoltage Chopper Phases

This program module enables the overvoltage choppers when there are no overvoltage chopper faults. When the overvoltage choppers are enabled, OVCA_ON enables the execution of TMXFO and TMXGO program modules.

The TESTACT signal will also deblock the inverters if the parameters TMAGPP1, P2 and P3 are true and chopper control is activated (OVCA_ON)

The parameter TMAGPP4 will make it possible to switch from A-computer control to B-computer control.

4.5.6 TMXGO, Overvoltage Chopper Control Logic

This program module includes the elements for the overvoltage control logic.

It is possible to deblock the overvoltage choppers as soon as the computer has started and the parameter DEBLOCP is set to true.

There are two ways of deblocking the choppers. When the switch on the control cubicle is in position ON, deblock is ordered by the signal:

DEBLOCH1 for the TMA overvoltage chopper

DEBLOCH2 for the TMB overvoltage chopper

DEBLOCH3 for overvoltage chopper 1 and 2 in AUX module.

If the control cubicle switch is in the position TEST, all choppers will be deblocked and an output reference will be sent to the choppers.

When the the signal DISCHARGE is True the overvoltage choppers are turned on for a short time to "take down" the line capacitor voltage.

The signal LVGTZERO is set when any of the three DC-link voltages are exceeding P11 volt. However, a "time out" circuit is also provided that will force this signal to zero P01 ms after the linebreaker is opened. The reason for this is to avoid an undefined mode of operation where the overvoltage choppers not has succeded to bring the DC-link voltage to zero in all three modules. If there is no time out circuit the alternative is to wait several minutes until the bleeder resistors have discharged the DC-link.

All time-parameters that are transmitted to the slave computer DTCC102B, must be multiplied by 0,8. The reason is that in the slave computer system definition the level I1 is set to 2 ms, but the true interrupt level is 2,5 ms.

4.6 Friction Brake Control

4.6.1 CA1BB, Brake Blending

The main task of the brake blending system is to produce the correct mixture of dynamic and friction brake at every moment.

The basic brake blending function will compare the required braking effort with the recieved dynamic braking effort. If there is any difference between these two signals, the dynamic brake does not produce enough braking effort, and we must add some amount of friction brake to achieve the requested braking rate. Of course the difference between the required effort and the recieved effort gives the exact amount of the friction brake necessary.

The figure below shows the basic principle of the blending function:

At car loads between AW2 and AW3, friction brake must be added to the dynamic brake to achieve the requested retardation rate. This will be done by the basic blending function, since the recieved dynamic brake effort not will correspond to the requested brake effort, in this case.

When the emergency brake is activated the blending function will be cut out, since dynamic brake may be added to the emergency friction brake.

4.6.2 CA1BC, Friction Brake at Low Speed

The friction brake will be reduced just before the speed is zero. This function will be implemented to cause a smooth stop for the car. After an appropriate short time interval following the stop, normal braking performance will be restored. Note that this brake reduction function will be active only if a peak speed of 15 mph or more was reached since the last stop.

At a speed as low as possible (CA&11BCP07 mph) the dynamic brake will fade out and the friction brake will gradually replace the dynamic brake. Instead of the friction brake reference from the brake blending, the total brake reference will become the output of this program module.The reduction of the dynamic brake is made in the CA&11BN program module.

4.6.3 CA1BF, Friction Brake Freeze at Slide Condition

4.6.4 CA1BV, Friction Brake Valves Control

This subfunction controls the friction brake valves. The output are the three digital control signals to the friction brake unit. These signals correspond to the three trainlines B1, B2 and B3 when friction brake only is demanded.

There are only five friction brake levels available in normal mode, and one for emergency braking. They are coded in the same way as the five lowest braking commands are coded on the trainlines.

When the exact amount of the required friction brake is determined, the nearest of the five possible friction brake levels is chosen, and the code corresponding to that level is put out to the friction brake unit.

Friction brake level Condition Code: B1 B2 B3

1 REQFRBF&AA > BRAKE1(A,B) X - X

2 REQFRBF&AA > BRAKE2(A,B) - - X

3 REQFRBF&AA > BRAKE3(A,B) X X -

4 REQFRBF&AA > BRAKE4(A,B) - X -

5 REQFRBF&AA > BRAKE5(A,B) X - -

Emergency EMBRAKE = true - - -

Brake level Brake pressure

0 0 (psi) = 0 (bar)

1 12 0.8

2 19 1.3

3 25 1.7

4 31 2.1

5 37 2.5

Em 43 3.0

4.6.5 CA1BG, Dump Valves Control

The task of this subfunction is to control the dump valves to the friction brake system.

In case of slide, the friction brake will be released. In order to accomplish this as fast as possible, the friction brake is released by the dump valves and not via the friction brake reference, on a per truck basis. The brakes are being released until they are completely released or until slide is no more present. The brakes are then slowly applied again by pulsating the dump valves. By switching between mode 1,1 and 0,1 , the brakes are slowly released and by switching between 0,0 and 0,1 they are slowly applied.

"release valve" "hold valve"

normal, brake apply 0 0

hold 0 1

not allowed 1 0

release 11 1 Figure

The system consists of following parts:

A counter (.240) that simulates the actual braking pressure by counting between the limits set by parameter P07 (min pressure) and P06 (max pressure).

A latch (.130) that latches the current value of the counter when SLIDE appears.

A comparator element (.160) that will set the valves to Normal (0,0) when counter has counted to previous latched value plus a number of counts set by parameter P02.

A comparator element (.170) that will give an initial apply pulse with a length that increases braking pressure to P03 percent of the value the counter had prior to the SLIDE signal. A "16384" value of P03 equals 100 %..

A counter (.180) that will give a pulse train defined by the parameters P04 (or P08 at low speed) and P05. This pulse train will determine the rate of increasing braking pressure. P04 (or P08 at low speed) is the time between each Normal pulse (0,0) and P05 is the duration of the Normal pulses. Low speed and high speed is set with parameters P10 (upper limit for high speed) and P09 (lower limit for low speed). The reason for this is to avoid long reapplication times at low speed. The system works in following way:

When SLIDE signal is set true the counter .240 will be reset and the two antislid valves will be set to Dump (1,1). The value that the counter had prior to the SLIDE signal will be latched in element .130.

When the SLIDE signal goes false, the counter will start counting. As long as the counter value is less than P03 percent of the previos value the counter will count rapidly (element .170 is true) and antiskid valves will be in the Normal position (0,0), increasing the braking pressure.

When P03 percent of the counting value is reached element .170 will go false and thus force the antislid valves to Hold position (0,1). After this point the counter (and the pressure) is increased for each count of the counter .180. The pressure is increased during the P05 ms and hold constant during the waiting time P04 ms (or P08 ms at low speed).

When the counter, finally, has reached the latched value in element .130 with the added number of counts (P02) the antiskid valves are set to Normal and thus applying normal pressure to the brakes again.

4.6.6 CA1FB, Friction Brake Supervision

This program module monitores the function of the friction brakes and the dump valves.

The friction brakes are checked in two ways:

The output BCU control order are red back via input board and the status is checked.

When a brake order is given (any of the three BCU control signals are made active) a check is made that the pressure switch indicates pressure.

The program module also supervises the dump valve signals. The outputs from Dump Valves Control Logic module (ASKREL&AAO and ASKHOL&AAO resp) are read and compared with the actual given orders to the dump valves (ASKREL_&AA and ASKHOL_&AA resp).

If there is a fault indicated, a fault text is displayed on the FIS display. Limitations will take place that restricts the performance of the car ATC cut out limits.